The Xtal Set Society Newsletter

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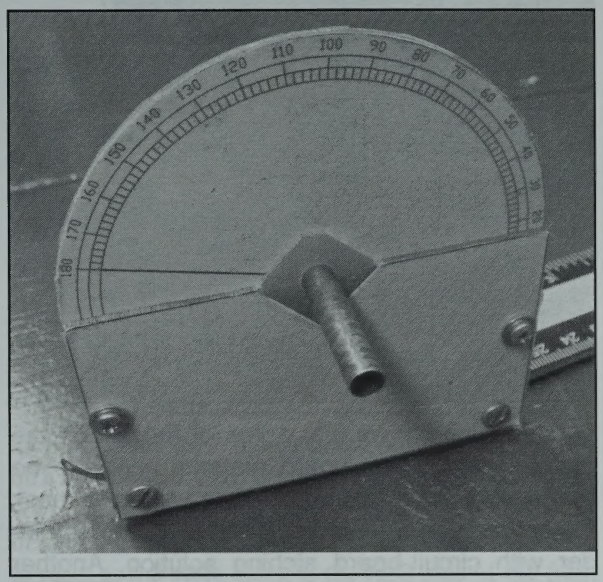
The Disappearing Variable Capacitor

by Dan Petersen, W7OIL

As our march forward in technology continues there are many wonders to behold. A single home computer has more computing power than all the computers in the world in 1960, instant communications around the world, hundreds of TV networks to choose from (and it was thought TV was a "vast wasteland" in the 1960's!) and of course that all-time favorite – texting while driving. On the flip side, those of us who still have a desire to build electronics of the traditional variety finds component parts becoming hard to find. Back in the "good old days" parts were to be had cheaply and there was no end of WW2 surplus electronic gear to modify or strip for parts. Sadly, for the vintage radio experimenter those days are long past.

One of the major components used in vintage construction is the venerable variable capacitor. While there is still at least one manufacturer in the US the VC is becoming an expensive item. But what if you are one of those folks who like to roll their own? There have been articles on making your own variable capacitor. One article that has appeared in the pages of this publication is the "sliding variable capacitor" in Mike Peebles' "Gilligan's Radio". There was another design from the early days of radio called the "book capacitor". The capacitor I am to describe here is a more conventional design from Europe. Conventional as it has a rotor turned by a shaft between two stators.



I would consider this an "intermediate" challenge to build. It is made with hand-tools and the only "hard" part to find would be the double-sided circuit board.

Ya gotta start somewhere!

And with this project you will need some double-sided circuit board, a short length of ¼" brass tubing from the hobby shop, some 6-32 hardware for fasteners and finally some self-stick paper and stick-on clear laminating sheet from the local office supply store. Figure 1 shows what the front and back of the capacitor look like when finished. It is all white in color, as I have covered the prepared double-sided board with first a layer of self-stick paper and then a layer of stick-on laminate. These layers are necessary as the rotor and stators must be insulated from one another.

Figure 2 shows the dimensions of the required

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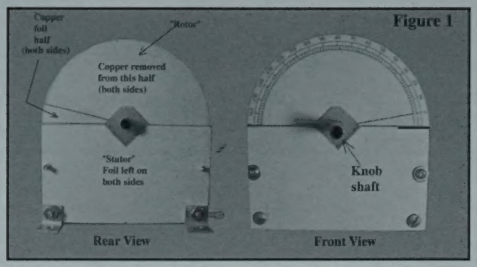
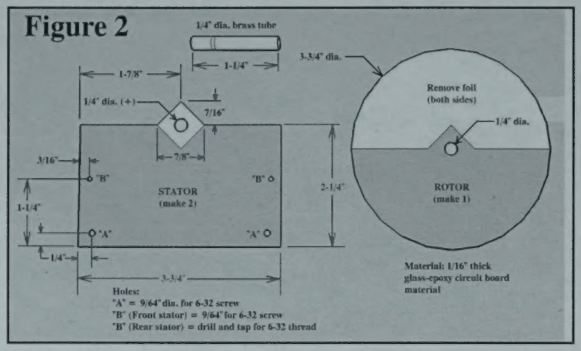


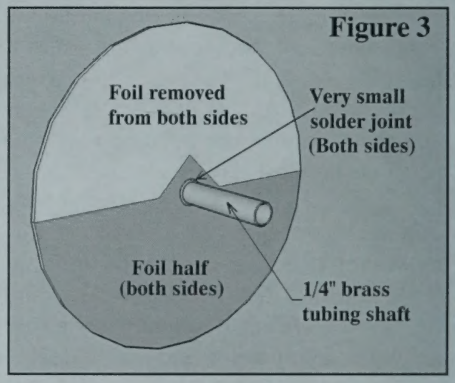


parts. It also shows that some of the foil on the double-sided circuit board material needs to be removed. How is this done? One way is to mask the copper you want to keep and etch the remainder with circuit-board etching solution. Another way is more tedious but it doesn't involve the possibility of dissolving important body parts or getting that crap in your eyes. My method is to score lines into the board's copper you want to remove. Be sure to wear eye protection when you do this. With a utility knife score the removal area into ¼" strips, then use a hot soldering iron to loosen an edge with the knife. Now that a corner is pulled up you can use the iron on the strip in front of the pulled corner to loosen the adhesive and, using the pliers, pull up the strip while sliding the iron along the strip. It sounds complicated but with a bit of practice it gets pretty routine. One-quarter inch holes need to be drilled into the rotor and stator pieces. You will note in Figure 2 that the holes in the stators specify"¼" dia (+)". This means the holes should be *just over* ¼" in diameter. An easy way to do that if you don't just happen to have a 17/64" drill bit is to take a small rat-tail file and *slightly* enlarge the hole. You want the shaft to turn freely in those holes.

The other holes in the stators are for the mounting hardware. The two stators are identical EXCEPT for the 2 holes in each marked "B". For the front stator you drill a 9/64" hole at location "A" and "B". For the rear stator location "A" is drilled 9/64" but "B" is drilled with a smaller 7/64" (#35) bit and threaded with a 6-32 tap.

Constructing the rotor.

The same procedure is used to remove unwanted copper from both sides of the rotor. Note that there is an area in the center where copper remains. This is so the shaft can be securely soldered to both sides of the copper foil. There is one slight problem? How do you keep the shaft perfectly perpendicular to the rotor? If it isn't the shaft will "wobble" and the assembly will jam up. My solution to that is to obtain a thread-spool to use as a mandrel. Most thread spools have a center hole a bit larger than the ¼" shaft diameter. Wrap a small strip of writing paper around the brass tube so that it slides snugly into the spool-hole and that about 5/16" sticks out of the top. Now push the rotor onto the shaft and make sure that it is flush against the top of the spool. In this way the shaft will be aligned properly with the rotor. Now for the soldering. Make sure the brass tubing and the copper foil are clean and shiny. Apply soldering paste to the joint of the shaft and the rotor. Don't worry if you think you have too much paste on it – it cleans off later. Apply at least a 60-watt iron to the joint and when the flux boils apply a SMALL amount of solder to the joint, NOT the iron. When hot enough the solder should flow smoothly around the joint. You may have to coax it a bit with the iron but you don't want a glob of solder on the



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joint. Once cooled to the point where you don't fry your fingers flip the rotor over and solder the joint on the other side using the same technique.

Assembling the critter.

After soldering the rotor, hold the rotor by the shaft and spin the rotor. It should turn evenly without wobble. Clean the rotor and stators with alcohol to remove any residual paste flux. Cover all surfaces with first self-stick paper and then the clear laminate. Cut the paper and laminate a bit oversize as you can trim any excess with a hobby-knife. For the rotor cut a small hole in the material with a paper-punch. Once all the parts are gathered together you can start assembly. Figure 4 is an exploded diagram of the assembly. The shaft and rotor have already been mated at this point. Push the short end of the shaft through the ¼" hole in the rear stator, and then push the front stator onto the long end of the shaft until the three parts make a "sandwich". Figure 5 is an edge view of the completed capacitor. A 6-32 by ¾" machine screw is passed through the hole marked "A" in the front stator, then two #6 washers for spacing for the rotor, then through the rear stator and a mounting bracket. The whole thing is then secured with a 6-32 nut and #6 lock-washer. The same is done with the other hole marked "A". For the "B" holes, the screw is passed through the front stator and *threaded* through the rear stator. No spacing washers are involved. When the whole "sandwich" is together give the shaft a turn. It should turn all the way around without binding. The upper screws are for tension adjust. Very slightly tighten the screws for the best "feel" when turning the shaft.

In Figure 1, the front view (right side) shows a scale on

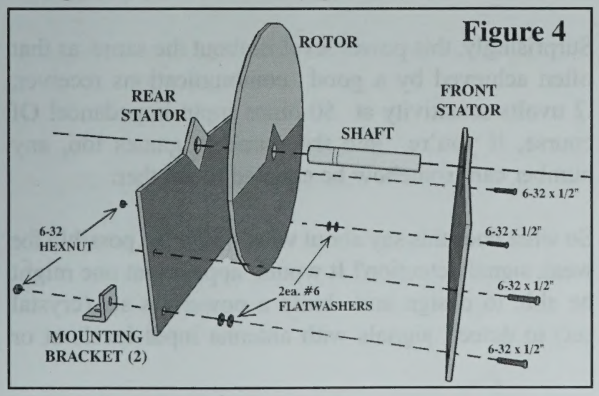

Figure 4

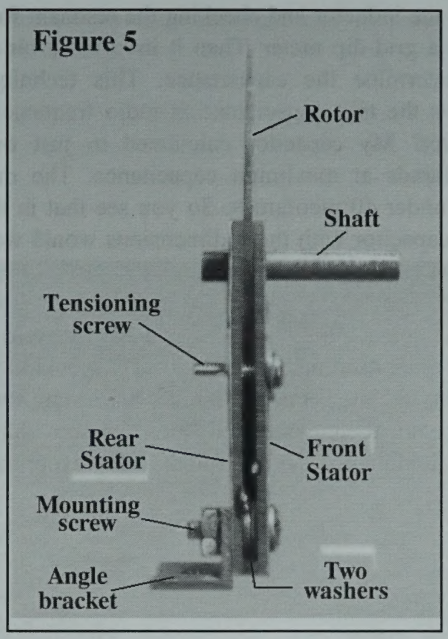

Figure 5

the rotor. This scale indicates the position of the rotor on a 0-100 scale. Zero is maximum capacitance. I drew the scale on AutoCAD, and then printed it onto a sheet of self-stick paper. The scale can be a little confusing to read, as the scale index is the right side of the front stator.

Connecting to the outside world.

Placing a solder-terminal to either of the bottom mounting screws can make the connection for the stator. The rotor can connect to the outside world by soldering a piece of fine wire to the short end of the shaft. That wire can be run loosely to wherever it needs to go (usually the common of the circuit) and can have a loop or two in it to relieve stress on the wire while turning the shaft.

When I finished mine I measured it using an inductor of a known value, hooking the capacitor in parallel

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with the inductor and checking the resonant frequency with a grid-dip meter. Then it involves a bit of math to determine the capacitance. This technique also shows the true capacitance at radio frequencies. The verdict? My capacitor calculated to just over 300 picofarads at maximum capacitance. The minimum was under 40 picofarads. So you see that in this case this capacitor with these dimensions would work well at AM broadcast frequencies.

While some folks think this is a hard way to make a project that the modern (?) world left behind decades ago my feeling is that the builder is learning something and using their hands and brain for something other than holding a game-controller. Keep experimenting!

Biasing for Slightly More Volume With a Basic Crystal set

Xtal Staff

Old-time crystal set builders discovered some time ago that a bit more volume can sometimes be had with a bare bones crystal set by adding some bias to the detecting diode. In our schematic, we've added a one meg-ohm resistor, 100 K pot and a +12 volt DC supply. By adjusting these bias parts, the DC bias at the anode (the positive lead of the diode) can be increased to a positive value of ~ 0.1 to 0.3 volts. This result can sometimes be an increase in volume of weak signals.

By providing 2 to 12 volts at the bottom of the one-meg-ohm resistor, 0.1 to 0.6 volts can be developed at the anode of the diode. For a germanium diode, we've found that about .1 volt of bias brings up the sensitivity of the diode by a factor of 2 or 3. More audio volume from a weak signal is definitely heard and may make the difference of hearing or not hearing a signal at all! I can't hear my local station when using a 1N914 diode (with a breakpoint of about 0.6 volts) but can when using a 1N34 (with a breakpoint of about .3 volts). By biasing the 1N914, volume is adequate!

These questions may seem a bit weird but they are central to the basis for the crystal set. First of all, the power of an AM radio signal must be high enough so that after detection you can hear the audio from it. Thinking in reverse we could say that the signal must have at least as much power as that required by the human ear for detection. Given that AM signals waste about one-half of their power in the RF carrier and that the detection process is less than ideal, we might expect to be able to design and build a crystal radio that could provide an audible audio signal when the RF received power is say tens times the threshold of hearing! That would indeed be a challenge.

So what is the lowest signal we can hear? A quick look into the audio chapter of my Reference Data for Radio Engineers (RDRE) indicates that the reference level of audio hearing is about 10'" -16 watts/em '" 2. If we assume that the effective aperture of the ear is about one square centimeter, then the power reference level for hearing is about 10" -16 watts. If we assume for a moment that a 50 ohm speaker could convert all of that power into audio, the voltage delivered to the speaker would be

P = (V" 2)/R or V = about .07 microvolts RMS!

Due to inherent losses in our system, let's assume that the power must be ten times that. Then the voltage must be

V "2 = (50) *10" ·15 or V = about .22 microvolts RMS!

Surprisingly, this power level is about the same as that often achieved by a good communications receiver, .2 uvolts sensitivity at 50 ohms input impedance! Of course, if you're into the numbers games too, any number can somehow be equated to another.

So what does this say about what might be possible for weak signal detection? It would appear that one might be able to design and build a powerless set (crystal set) to detect signals with antenna input levels at or

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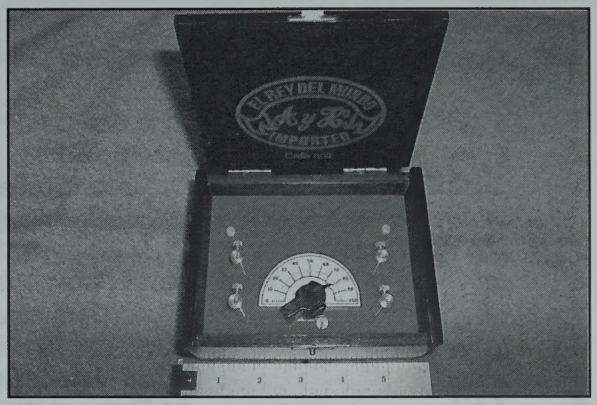
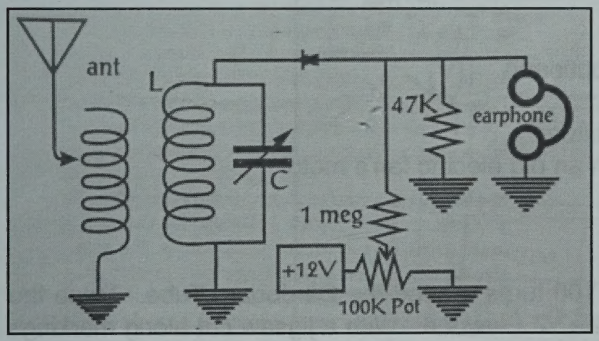
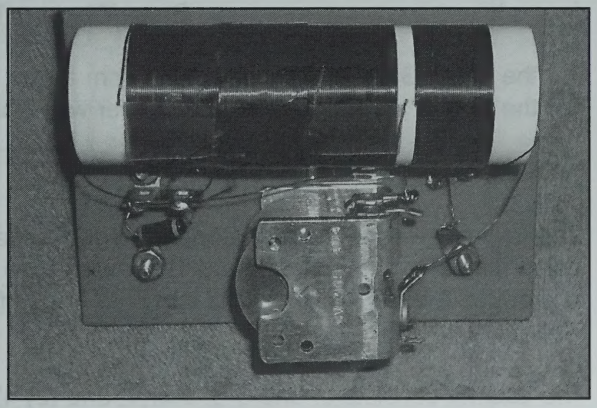
about a microvolt! While the ear can hear audio signals at these levels the problem lies in converting the RF signal to audio. Basically an ideal diode would be required, one that forward biases right at or just above zero volts, say .2 microvolts.

Alas, we are not going to do that with diodes even if we give them a bit of a boost with added bias. It would however seem possible to reach the millivolt level of detection with some sort of differential amplifier as a 'ideal diode' substitute for the our old faithful 1N34 germanium workhorse. But would this be a crystal set any longer? You might say no since transistors would now be involved and a DC supply would become necessary. The conclusion we must draw is that with ideal diodes (which don't exist in practice) and a perfect speaker (converts all of its signal to audio) we could receive and hear AM signals with a power level somewhat above the reference level of hearing. But, we're going to have to wait for ideal diodes and perfect speakers. So what do you think?







Lrry Jeffers could not resist one more Cigar Box radio.. Notice the coil.

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Double Slider Crystal Radio Set
by Jerry Lewandowski (circa 1998)

When I was a young boy back in the 1950's, I purchased a crystal set at a rummage sale for fifty cents. Ever since that time, I've been fascinated by crystal radio sets. So, from memory I constructed my own version of that set. The original crystal set was twice as big and had a walnut sized fixed crystal.

Materials:

1.	Qty. Size	Description
1	6" x 5" x 1" Thick	Pine Board
2	4" x 4" x 1" Thick	Pine Board
1	3 ½" Diameter x 4" Long	Cardboard Tube
	92 feet	#20 Gauge Copper Magnet Wire
1	8" x 4" ¼" thick	Plywood (for 2 Coil Disks)
8	½"	Brass Plated Brad Nails
1		IN34A Germanium Diode or any Sensitive Crystal
4		Post Type Binding Posts or Fahnstock Clips
4		Small Rubber Bumpers
8	1 ½"	#4 Flathead Wood Screws
2	5" x ¼"	Brass or Steel Round Rod
2	½"	Brass Balls
1	2'	Hookup Wire
4	½"	Brass Washers (optional)

For the Brass Balls I used pull chains from a light fixture.
For the copper wire I removed the copper wire from an old electric fan's motor.

Instructions:

Carefully close-wind the #20 Copper Magnet Wire 100 turns around the Cardboard Tube. Trace the inside diameter of the Cardboard Tube twice onto the ¼" Plywood. With a jigsaw cut along markings to produce 2 disks. Insert disks into both ends of the Cardboard Tube and secure with (8) ½" Brass Plated Brad Nails.

The cabinet consists of one 6" x 5" x 1" and (2) 4" x 4" x 1" Pine Boards that form the bookend style frame as seen in the pictorial diagram. The dimensions are not critical and may vary up to ½" in either way.

Secure Brass Balls with a vise and drill a hole in the center using a ¼" drill bit. Secure Steel Round Rod with a vise and drill a hole on each end using a 1/8" drill bit. Insert Brass balls onto Steel Round Rod ends. Brass Balls should slide easily.

Screw 5" Steel Round Rod onto the top center and the front center of the 4" Pine Boards as shown in illustration.

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Place Coil in BookEnd opening. Adjust Coil so that it aligns with the Brass Balls. Brass Balls should cut across the copper wire with ease. Secure Coil to frame with wood screws.

Drill (4) 1/8" holes on the frame base as shown in the illustration, and mount all small parts (Brass Washers, Binding Posts, and Rubber Bumper Feet). Run the entire hookup wiring as shown in the diagram.

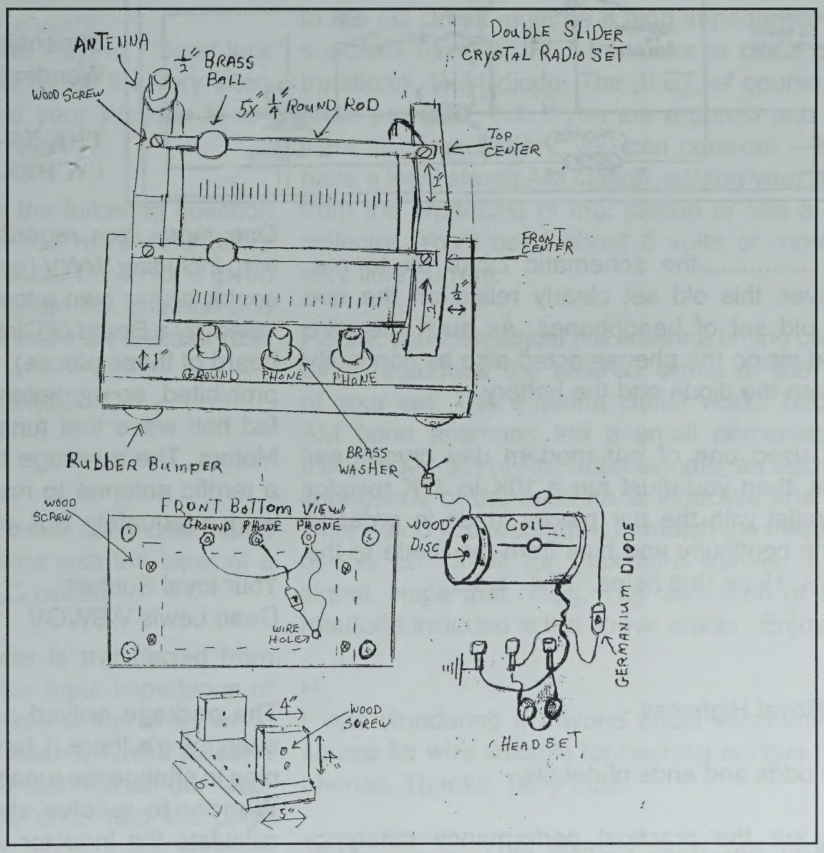
Get Ready to Test the Set

Use a good ground, aerial and a better quality headset.
I used a cold water pipe for the ground.
I stretched a 25' copper wire across my attic for the aerial.
I used a 1500 Ohms Dictograph Headset.

Move the top tuning Ball to different positions on the Coil; you should be able to pick up one or more stations in your vicinity. If you receive more than one radio station in one area on the Coil, move the lower tuning ball to separate radio stations. In most cases this will rectify the problem.

I received 3 different radio stations across the coil, loud and clear. And by using the sliding balls, I was able to clear up double stations with excellent results.

Try it you'll like it!



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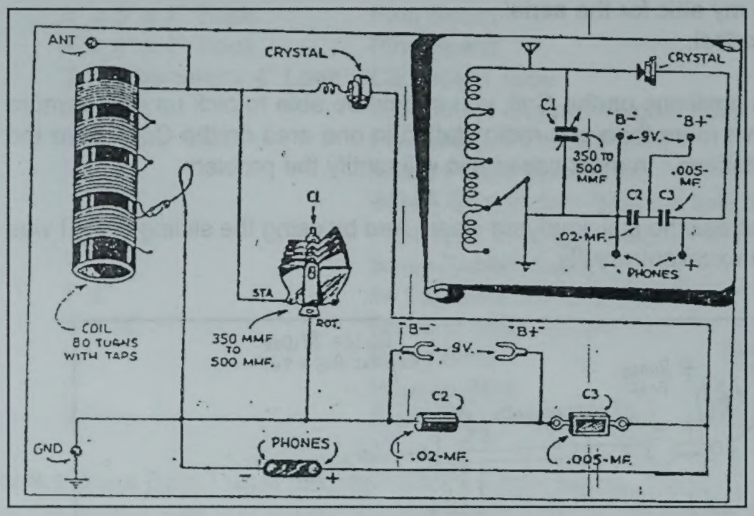
Xtal Corner:Member Correspondence

Phil,

I do not see how this can work.

Please see what you think. If it looks like it can't I wonder if it never did or it was drawn wrong in the magazine.

Thanks, Ken



Ken, ...the schematic looks ok to me. However, this old set clearly relied on the use a an old set of headphones. As such the wire wound inside the phones acted also as continuity between the diode and the battery.

I you used one of our modern day crystal ear pieces, then you must run a 10K to 47K resistor in parallel with the ear pieces leads in order to provide continuity and bias from the diode to the battery. Hope that helps. Phil w0xi

Your Royal Highness -

A few odds and ends of details:

What are the practical performance differences between your JFET Detector and Infinite Impedance Detector?

BOTH BOARDS PRESERVE THE HIGH IMPEDANCE OF THE LC CIRCUIT.....BUT THE IMPEDANCE DETECTOR SMOOTHS OUT THE AUDIO A BIT MORE BY FILTERING THE AUDIO RESPONSE. RESULT IS BETTER FIDELITY AUDIO WISE.

What are the circuit board dimensions of the Infinite Impedance Detector? The JFET Detector is listed as 2 x 1.4 inches.

THE INF IM DET PCB IS THE SAME SIZE AND THE JFET... ACTUALLY THE SAME BOARD, JUST DIFFERENT RESISTORS AND CAPACITORS USED TO ADJUST THE AUDIO.

Dimensions of the XS-402 Little Wonder?

THE XS-402 PCB IS 2-1/4 BY 2-3/4 INCHES.

One more item regarding my shortwave reception, including WWV (and my 2-way amateur radio contacts): we own a townhouse in a development 'ruled' by a Board of Directors (you've undoubtedly heard of these places), and outdoor antennas are prohibited, so my antenna is indoors; a 65 ft end fed half wave that tunes 40, 30, 20, 15, and 10 Meters. The message here is that it doesn't take a terrific antenna to make even simple receivers work adequately. But, you already knew that...

Your loyal Subject;
Dean Lewis W9WGV

The package arrived a couple of days ago, and everything's there. I have one problem; I'm planning to change the tuned circuit of the XS-402 Little **Wonder to receive shortwave frequencies.** To calculate the inductor value, I need to know the

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value of the compression trimmer capacitor, but I can't find it anywhere in the instructions, and the only identification on the trimmer is the number 427 printed on the side. Can you provide the value of this part? Thanks, Dean

Hello Dean,
Dean! The average range of values for the 427 mica adjustable cap is 70 to 220 pf. This will, of course, change from unit to unit a bit. Shortwave crystal sets are possible but generally not as effective given that the signals are weaker and the Q of LC circuits, let's say for WWV at 5 MHz, produce lower signals too – at the output of the diode detector. A big antenna would help some. If you add a small value cap in series with the 427 mica (or a regular 365 air variable cap), the combination will tune a lower and smaller range of capacitance, given a single coil value. Let us know how your experiment turns out. 73, Phil, WØXI.

Hi Patricia , Phil and Crew ,
$10.98 sent this morning via PayPal . Good luck to you all and many thanks for all the very interesting Newsletters . I have your Website in my "Favorites" for future reference.

Would you please ask Phil the following question for me regarding coils . Once I have determined the turns according to Professor Coyle for a given frequency how do you calculate the antenna and tickler number of turns ? Is there a particular ratio ?
Many thanks.Jim McGowan M0MAC

Jim,

Your question generically: How does one match the impedance of an antenna with the input of a crystal set, i.e. the tuned LC circuit?

Recall that maximum power is transferred from a source to a load when the input impedance of each is the same. An example of that is shown in Figure 2 of of the article titled **A Great Teacher: The Crystal Set**, which you can find on our website. Just click on the title once and the page comes up.

https://www.midnightscience.net/articles.html

Note in Figure 2 that the crystal set antenna is placed in series with an adjustable air variable capacitor. That combination is then connected to the top of the crystal set's tuned circuit. Design your LC circuit as you usually would and then adjust the antenna series capacitor for maximum volume while at the same time tuning the LC circuit for resonance (at the frequency desired).

Intuitively, here is what happens. For best results, the LC tuned circuit must have a high Q in order to have best gain and selectivity. That means on the AM band that your coil should have a inductance of about 200 to 250 micro-henry (uH) and the coil should be wound on **a low-loss coil form – such as PVC pipe**. In addition, for best results, use Litz wire for the coil or #22 AWG (solid enamel wire). Second, the RF-to-audio detector that you attach to the LC circuit must be a high impedance. That suggests using a JFET transistor in place of the traditional 1N34 diode. The JFET, of course, has to be powered; but, If you are a purest and don't want to use a battery, you can consider – if you have a local strong AM station, getting your power from the broadcast of that station or use a solar collector. You'll need about 3 volts or more but very little current.

Finally, you then adjust the antenna tuning capacitor to introduce the desired signal at the input of your set. The antenna circuit works because AM band antennas are a small percentage of the wavelength of AM radio signals; as such, the impedance of the antenna is inductive and fairly large – and you resonate it to match the frequency of the LC circuit for maximum transfer of the signal. Hope that helps. The derivation of these results is included in the above article. Enjoy, Phil

Hi,
I was wondering if anyone could recommend a source for wire suitable for rewiring antique headphones. Thanks, Terry Lutz

Terry.....not exactly sure but probably

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enamel wire with size 30 or 32.....we have in stock wire enamel 26...but that may be a little heavy.

If you have a sample, use calipers to measure the diameter of the wire and then look in the amateur radio handbook or web search for the # and dia of enamel wire.....guessing 30 or 32.
good luck, Phil, w0xi

Dear Queen Mum.

I was sad to see that the Society would no longer publish a newsletter. I have enjoyed it for some years now and will have a hard time finding something to replace it.

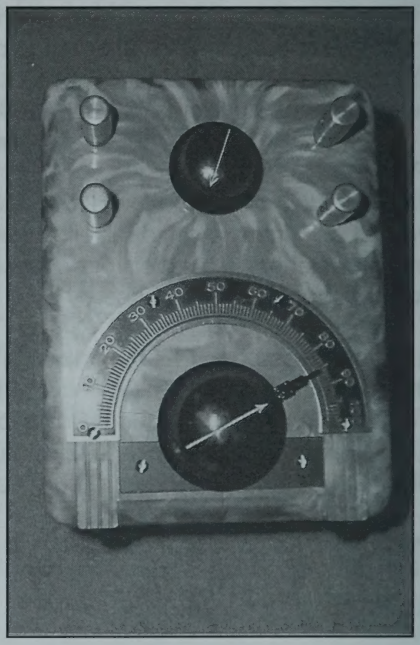
I have a PhD in Physics and taught Physics and did research in Physics at Texas Tech University for 40 years. However, I made my first crystal set (a foxhole set) in 1950. It worked fine.

A couple of years later, my Dad decided to get a new radio for my Grandmother and I got her Philco model 80 which is a TRF from 1929. I still have it and it works great. It did not need much repair. That started me off and I have had a hobby of renovating tube sets ever since.

I just finished a National NC 87 and that was fun. I am now working on the last two I will do (I think) a Collins 51J-4 and a Collins R390A. Be sure to show this letter to Phil because he will know what those are and he will know why those are my last two (expensive).

One of the things I have enjoyed over the years are the articles by Phil. He really gives the beginners good advice. I already know all that stuff but I enjoyed Phil's explanations.

Goodbye and thanks for all the fish. Lynn



Larry Jeffers had this box from a metronoym with a dial scale. He covered the scale with his own and made a radio with a 1 transistor Amp. The brass posts are from an atwater Kent radio.

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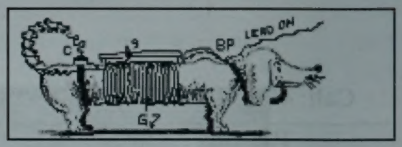


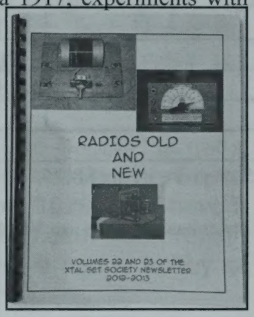
We are dedicated to once again building and experimenting with radio electronics, often—but not always—through the use of the crystal set, the basis for most modern day radio apparatus. This newsletter helps support our goal of producing excellent quality technical books that encourage learning and building.

Please send articles and correspondence to the following address:
PO Box 3636, Lawrence KS 66046

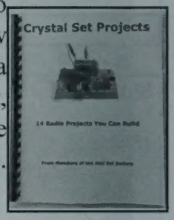
Nylon Form for Rod

This set of nylon parts combine as a form for the ferrite rod, thus preserving the Q of the rod mounted above a chassis. The Rod is not included. Nylon Form rod $2.50

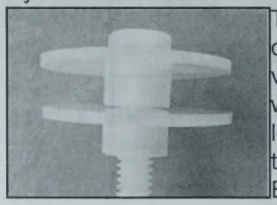
RADIOS OLD AND NEW is volumes 22 and 23 of the Xtal Set Society Newsletter. A wide range of topics and projects are covered in 2012: aerials circa 1917, experiments with regens, grounding and reducing noise in your station, experimenting with spider coils, a 2 for 1 regen set, primer for the 602 mixer at 40 kHz, a modern TRF AM receiver. The following topics for 2013 are: JFET Drain-Output set, a foxhole radio, feedback for beginners, a modern day regen, the universal crystal set, The Albert Hull Memorial Dynatron Regenerative Receiver, adding absorption wave traps, from telegrapher to coherer, a 700 Hz oscillator featuring a quadrature architecture, and more. Vol 23 $15.95



Crystal Set Projects You Can Build is a collection of 14 radio projects designed by members of the Xtal Set Society. The members hope that by creating this book they will help others to discover this great hobby while at the same time learning basic radio concepts. Here's a sampling: Low Budget Xtal Set, A Loop Antenna Crystal Set, The Den Two Crystal Set, Build a Matchbox Crystal Radio, The triple Tuned Crystal Set and more. XCP $12.95



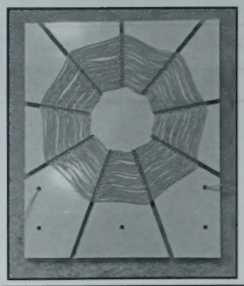
Nylon Form for Core



These nylon plastic pieces combine as a form for the various ferrite toroid coils we offer. The form is low loss thus preserving the Q of the coil wound on the form. Extending them above the chassis - which might be metal or fiber board also preserves the coil Q. nycore-frm $2.50

Spider Coil Form

This 5 by 6 by 1/8th inch ABS plastic form includes nine NC punched radial slots and five mounting holes. This size supports 250 uH coils when used with #22 or #26 enamel, or 150/45 Litz wire found on our website. The coil shown consists of 56 turns of 150/45 Litz, with a 1.6 inner diameter and 4.2 outer diameter. An instruction sheet including formula and table ships with the form. In addition, you'll find the spider formulas for number of turns for a given inductance on our formulas-calculators web page on our main site, www.midnightscience.com Spider Coil Form Cat #SpCO $9.95 each.



R-L-C-D Assortment

This assortment has nearly all the parts to build a basic am crystal set: 100 pf cap, 330 pf cap, am-band toroidal coil form (ft-82-61), 47k and 100k resistors and a 1n34 diode. RLCD 5.95

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